

We claim:

1. A method for supporting virtual private networks in a label switched communication system having an ingress device in communication with an egress device via a number of intermediate devices, the method comprising:

including label information and a virtual private network identifier in Next Hop Resolution Protocol messages, the virtual private network identifier identifying a virtual private network; and

using said Next Hop Resolution Protocol messages to dynamically establish a label switched path for the virtual private network.

2. The method of claim 1, wherein the label information and the virtual private network identifier is included within a Next Hop Resolution Protocol message in a type-length-value field having at least a virtual private network identifier field for carrying the virtual private network identifier and a label information field for carrying the label information.

3. The method of claim 1, wherein using said Next Hop Resolution Protocol messages to dynamically establish a label switched path for the virtual private network comprises using said Next Hop Resolution Protocol messages to dynamically establish a label switched path for a forward path from the ingress device to the egress device for the virtual private network.

4. The method of claim 3, wherein using said Next Hop Resolution Protocol messages to dynamically establish the label switched path for the forward path from the ingress device to the egress device for the virtual private network comprises:

sending a Next Hop Resolution Protocol request message by the ingress device;

forwarding the Next Hop Resolution Protocol request message hop-by-hop from the ingress device to the egress device by each intermediate device that is on the forward path;

sending a Next Hop Resolution Protocol reply message by the egress device; and

forwarding the Next Hop Resolution Protocol reply message hop-by-hop from the egress device to the ingress device by each intermediate device that is on the forward path.

5. The method of claim 4, wherein the Next Hop Resolution Protocol request message is a Next Hop Resolution Protocol Resolution Request message, and wherein the label information comprises a label request.

6. The method of claim 4, wherein the Next Hop Resolution Protocol reply message is a Next Hop Resolution Protocol Resolution Reply message, and wherein the label information comprises label mapping information.

7. The method of claim 4, wherein the Next Hop Resolution Protocol reply message is a Next Hop Resolution Protocol Label Mapping message, and wherein the label information comprises label mapping information.

8. The method of claim 4, wherein forwarding the Next Hop Resolution Protocol request message by an intermediate device comprises:  
receiving the Next Hop Resolution Protocol request message from a previous hop device on the forward path;  
maintaining previous hop state information for said previous hop device; and  
forwarding the Next Hop Resolution Protocol request message to a next hop device on the forward path.

9. The method of claim 8, wherein forwarding the Next Hop Resolution Protocol reply message by an intermediate device comprises:  
receiving a first Next Hop Resolution Protocol reply message from a next hop device on the forward path;  
allocating a forward path label for a label switched path segment from a previous hop device on the forward path to said intermediate device; and  
sending a second Next Hop Resolution Protocol reply message including said forward path label and the virtual private network identifier to said previous hop device on

the forward path based upon the previous hop state information.

10. The method of claim 4, wherein forwarding the Next Hop Resolution Protocol request message by an intermediate device comprises:

5 receiving the Next Hop Resolution Protocol request message from a previous hop device on the forward path, the Next Hop Resolution Protocol request message including a forward path address list;

adding an intermediate device address to the forward path address list in the Next Hop Resolution Protocol request message; and

10 forwarding the Next Hop Resolution Protocol request message including the forward path address list to a next hop device on the forward path.

11. The method of claim 10, wherein the forward path address list comprises a Next Hop Resolution Protocol Forward Transit NHS Record Extension field.

12. The method of claim 4, wherein forwarding the Next Hop Resolution Protocol reply message by an intermediate device comprises:

15 receiving a first Next Hop Resolution Protocol reply message from a next hop device on the forward path, the Next Hop Resolution Protocol reply message including a return path address list including at least an address of a previous hop device on the forward path;

20 allocating a forward path label for a label switched path segment from a previous hop device on the forward path to said intermediate device; and

25 sending a second Next Hop Resolution Protocol reply message including said forward path label and the virtual private network identifier to said previous hop device on the forward path based upon the address in the return path address list.

13. The method of claim 4, wherein sending a Next Hop Resolution Protocol reply message by the egress device comprises:

30 receiving the Next Hop Resolution Protocol request message from a previous hop device on the forward path;

allocating a forward path label for a label switched path segment from said previous hop device on the forward path to the egress device; and

5 sending the Next Hop Resolution Protocol reply message including said forward path label and the virtual private network identifier to said previous hop device on the forward path.

14. The method of claim 13, wherein the Next Hop Resolution Protocol request message includes a forward path address list including at least an address of the previous hop device on the forward path, and wherein sending the Next Hop Resolution Protocol  
10 reply message to the previous hop device on the forward path comprises sending the Next Hop Resolution Protocol reply message to the previous hop device on the forward path based upon the address in the forward path address list.

15. The method of claim 1, wherein using said Next Hop Resolution Protocol messages to dynamically establish a label switched path for the virtual private network comprises using said Next Hop Resolution Protocol messages to dynamically establish a label switched path for a return path from the egress device to the ingress device for the virtual private network.

16. The method of claim 15, wherein using said Next Hop Resolution Protocol messages to dynamically establish the label switched path for the return path from the egress device to the ingress device for the virtual private network comprises:

sending a Next Hop Resolution Protocol request message by the ingress device;  
and

25 forwarding the Next Hop Resolution Protocol request message hop-by-hop from the egress device to the ingress device by each intermediate device that is on the forward path.

17. The method of claim 15, wherein sending the Next Hop Resolution Protocol request message by the ingress device comprises:

allocating a return path label for a label switched path segment from a next hop

device on the forward path to the ingress device; and

sending the Next Hop Resolution Protocol request message including said return path label and the virtual private network identifier to said next hop device on the forward path.

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18. The method of claim 15, wherein forwarding the Next Hop Resolution Protocol request message by an intermediate device comprises:

receiving a first Next Hop Resolution Protocol request message from a previous hop device on the forward path;

10 allocating a return path label for a label switched path segment from a next hop device on the forward path to the intermediate device; and

sending a second Next Hop Resolution Protocol request message including said return path label and the virtual private network identifier to said next hop device on the forward path.

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19. A device for supporting virtual private networks in a label switched communication system, the device comprising label switching logic operably coupled to establish a label switched path for the virtual private network using Next Hop Resolution Protocol messages, wherein the label switching logic includes a label request and a virtual private network identifier in Next Hop Resolution Protocol request messages, and wherein the label switching logic includes label mapping information and the virtual private network identifier in Next Hop Resolution Protocol reply messages.

20. The device of claim 19, wherein the label switching logic comprises:  
transmitting logic operably coupled to transmit to a next hop device in the communication network a Next Hop Resolution Protocol request message including a label request and the virtual private network identifier; and  
receiving logic operably coupled to receive from said next hop device in the communication network a Next Hop Resolution Protocol reply message including a forward path label for a label switched path segment to said next hop device in the communication network and the virtual private network identifier.

21. The device of claim 20, wherein the label switching logic is operably coupled to establish the label switched path to said next hop device in the communication network using said forward path label.

22. The device of claim 20, wherein the label switching logic further comprises return path label allocation logic operably coupled to allocate a return path label for a label switched path segment from said next hop device in the communication network, and wherein the transmitting logic is operably coupled to transmit to said next hop device in the communication network the Next Hop Resolution Protocol request message including said return path label in addition to the label request and the virtual private network identifier.

23. The device of claim 19, wherein the label switching logic comprises:  
request message receiving logic operably coupled to receive from a previous hop

device in the communication network a first Next Hop Resolution Protocol request message including a label request and the virtual private network identifier;

request message transmitting logic operably coupled to transmit to a next hop device in the communication network a second Next Hop Resolution Protocol request message including the label request and the virtual private network identifier;

reply message receiving logic operably coupled to receive from said next hop device in the communication network a first Next Hop Resolution Protocol reply message including label mapping information and the virtual private network identifier;

forward path label allocation logic operably coupled to allocate a forward path label for a label switched path segment from the previous hop device in the communication network; and

reply message transmitting logic operably coupled to transmit to said previous hop device in the communication network a second Next Hop Resolution Protocol reply message including said forward path label and the virtual private network identifier .

24. The device of claim 23, wherein the request message receiving logic is operably coupled to maintain previous hop state information for said previous hop device in the communication network, and wherein the reply message transmitting logic is operably coupled to transmit the second Next Hop Resolution Protocol reply message to said previous hop device in the communication network based upon the previous hop state information.

25. The device of claim 23, wherein the first Next Hop Resolution Protocol request message includes a forward path address list, and wherein the label switching logic is operably coupled to insert a device address into the forward path address list and include the forward path address list in the second Next Hop Resolution Protocol request message.

26. The device of claim 25, wherein the forward path address list comprises a Next Hop Resolution Protocol Forward Transit NHS Record Extension field.

27. The device of claim 25, wherein the first Next Hop Resolution Protocol reply

message includes a return path address list including at least an address for said previous hop device in the communication network, and wherein the reply message transmitting logic is operably coupled to transmit the second Next Hop Resolution Protocol reply message to said previous hop device in the communication network based upon the address in the list of addresses.

28. The device of claim 27, wherein the reply message transmitting logic is operably coupled to remove an address from the return path address list to form a modified return path address list and to include the modified return path address list in the second Next Hop Resolution Protocol reply message.

29. The device of claim 23, wherein the first Next Hop Resolution Protocol request message includes a return path label for a label switched path segment to said previous hop device, and wherein the label switching logic is operably coupled to establish a label switched path to said previous hop device using said return path label.

30. The device of claim 23, wherein the label switching logic further comprises return path label allocation logic operably coupled to allocate a return path label for a label switched path segment from said next hop device in the communication network, and wherein the request message transmitting logic is operably coupled to transmit to said next hop device in the communication network the second Next Hop Resolution Protocol request message including said return path label in addition to the label request and the virtual private network indicator.

31. The device of claim 19, wherein the label switching logic comprises:  
receiving logic operably coupled to receive from a previous hop device in the communication network a Next Hop Resolution Protocol request message including a label request and the virtual private network identifier;  
forward path label allocation logic operably coupled to allocate a forward path label for a label switched path segment from said previous hop device in the communication network; and





36. A program product comprising a computer readable medium having embodied therein a computer program for supporting virtual private networks in a label switched communication system, the computer program comprising label switching logic programmed to establish a label switched path for the virtual private network using Next Hop Resolution Protocol messages, wherein the label switching logic is programmed to include a label request and a virtual private network identifier in Next Hop Resolution Protocol request messages, and wherein the label switching logic is programmed to include label mapping information and the virtual private network identifier in Next Hop Resolution Protocol reply messages.

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37. The program product of claim 36, wherein the label switching logic comprises: transmitting logic programmed to transmit to a next hop device in the communication network a Next Hop Resolution Protocol request message including a label request and the virtual private network identifier; and receiving logic programmed to receive from said next hop device in the communication network a Next Hop Resolution Protocol reply message including a forward path label for a label switched path segment to said next hop device in the communication network and the virtual private network identifier.

38. The program product of claim 37, wherein the label switching logic is programmed to establish the label switched path to said next hop device in the communication network using said forward path label.

39. The program product of claim 37, wherein the label switching logic further comprises return path label allocation logic programmed to allocate a return path label for a label switched path segment from said next hop device in the communication network, and wherein the transmitting logic is programmed to transmit to said next hop device in the communication network the Next Hop Resolution Protocol request message including said return path label in addition to the label request and the virtual private network identifier.

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40. The program product of claim 36, wherein the label switching logic comprises:  
request message receiving logic programmed to receive from a previous hop device  
in the communication network a first Next Hop Resolution Protocol request message  
including a label request and the virtual private network identifier;

5 request message transmitting logic programmed to transmit to a next hop device in  
the communication network a second Next Hop Resolution Protocol request message  
including the label request and the virtual private network identifier;

reply message receiving logic programmed to receive from said next hop device in  
the communication network a first Next Hop Resolution Protocol reply message including  
10 label mapping information and the virtual private network identifier;

forward path label allocation logic programmed to allocate a forward path label for  
a label switched path segment from the previous hop device in the communication  
network; and

reply message transmitting logic programmed to transmit to said previous hop  
15 device in the communication network a second Next Hop Resolution Protocol reply  
message including said forward path label and the virtual private network identifier .

41. The program product of claim 40, wherein the request message receiving logic is  
programmed to maintain previous hop state information for said previous hop device in  
the communication network, and wherein the reply message transmitting logic is  
20 programmed to transmit the second Next Hop Resolution Protocol reply message to said  
previous hop device in the communication network based upon the previous hop state  
information.

25 42. The program product of claim 40, wherein the first Next Hop Resolution Protocol  
request message includes a forward path address list, and wherein the label switching logic  
is programmed to insert a device address into the forward path address list and include the  
forward path address list in the second Next Hop Resolution Protocol request message.

30 43. The program product of claim 42, wherein the forward path address list comprises  
a Next Hop Resolution Protocol Forward Transit NHS Record Extension field.

44. The program product of claim 42, wherein the first Next Hop Resolution Protocol reply message includes a return path address list including at least an address for said previous hop device in the communication network, and wherein the reply message transmitting logic is programmed to transmit the second Next Hop Resolution Protocol reply message to said previous hop device in the communication network based upon the address in the list of addresses.

45. The program product of claim 44, wherein the reply message transmitting logic is programmed to remove an address from the return path address list to form a modified return path address list and to include the modified return path address list in the second Next Hop Resolution Protocol reply message.

46. The program product of claim 40, wherein the first Next Hop Resolution Protocol request message includes a return path label for a label switched path segment to said previous hop device, and wherein the label switching logic is programmed to establish a label switched path to said previous hop device using said return path label.

47. The program product of claim 40, wherein the label switching logic further comprises return path label allocation logic programmed to allocate a return path label for a label switched path segment from said next hop device in the communication network, and wherein the request message transmitting logic is programmed to transmit to said next hop device in the communication network the second Next Hop Resolution Protocol request message including said return path label in addition to the label request and the virtual private network indicator.

48. The program product of claim 36, wherein the label switching logic comprises: receiving logic programmed to receive from a previous hop device in the communication network a Next Hop Resolution Protocol request message including a label request and the virtual private network identifier;

forward path label allocation logic programmed to allocate a forward path label for a label switched path segment from said previous hop device in the communication

network; and

transmitting logic programmed to transmit to said previous hop device in the communication network a Next Hop Resolution Protocol reply message including said forward path label and the virtual private network identifier.

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49. The program product of claim 48, wherein the Next Hop Resolution Protocol request message includes a forward path address list, and wherein the transmitting logic is programmed to include the forward path address list as a return path address list in the Next Hop Resolution Protocol reply message.

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50. The program product of claim 48, wherein the Next Hop Resolution Protocol request message includes a return path label for a label switched path segment to said previous hop device in the communication network, and wherein the label switching logic is programmed to establish the label switched path to said previous hop device in the communication network using said return path label.

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51. The program product of claim 36, wherein the Next Hop Resolution Protocol request messages comprise Next Hop Resolution Protocol Resolution Request messages.

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52. The program product of claim 36, wherein the Next Hop Resolution Protocol reply messages comprise one of:

Next Hop Resolution Protocol Resolution Reply messages; and

Next Hop Resolution Protocol Label Mapping messages.

53. A communication system comprising an ingress device in communication with an egress device via a number of intermediate devices, wherein a label switched path is established for a virtual private network by including label information and a virtual private network identifier in Next Hop Resolution Protocol messages and using said Next Hop Resolution Protocol messages to dynamically establish the label switched path for the virtual private network.

54. The communication system of claim 53, wherein:

the ingress device sends a Next Hop Resolution Protocol request message including at least a label request and the virtual private network identifier to a next hop device on a forward path from the ingress device to the egress device;

each intermediate device on the forward path forwards the Next Hop Resolution Protocol request message to a next hop device on the forward path;

the egress device sends a Next Hop Resolution Protocol reply message including at least forward path label mapping information and the virtual private network identifier to a previous hop device on the forward path; and

each intermediate device on the forward path forwards the Next Hop Resolution Protocol reply message to a previous hop device on the forward path.

55. The communication system of claim 54, wherein the ingress device further includes return path label mapping information in the Next Hop Resolution Protocol request message, and wherein each intermediate device on the forward path further includes return path label mapping information in the Next Hop Resolution Protocol request message.

56. A protocol message comprising:  
a virtual private network identifier identifying a virtual private network for the  
protocol message; and

label information relating to a label switched path associated with the virtual  
private network.

57. The protocol message of claim 56 embodied as a next hop resolution protocol  
message.

58. The protocol message of claim 56, wherein the label information comprises label  
request information.

59. The protocol message of claim 56, wherein the label information comprises label  
mapping information.

60. The protocol message of claim 56 embodied in a carrier wave for transmission over  
a communication network.